Specifications for Deep Ultra-Violet Photolithographic Mask Aligner System

Section 1. General Requirements

1.1 Scope. This specification describes the minimum technical requirements and the minimum acceptable performance standards for a deep ultra-violet (DUV) photolithographic mask aligner to be installed by the contractor at the Naval Research Laboratory (NRL). The system will be used by NRL personnel to transfer patterns from a shadow mask to a silicon wafer using contact photolithography.

1.2 Installation Site. The mask aligner will be placed in a multiple-user clean-room facility in Building 3, Naval Research Laboratory, Washington, D.C. 20375, at a specific location to be designated by the NRL's Technical Manager (TM). The laboratory utilities include 115 and 208 volts alternating current (VAC), single phase, 60 Hertz (Hz) electrical power and vacuum, compressed air and compressed dry nitrogen supply. The contractor must install the system in a manner consistent with typical Class 1000 clean-room operating procedures.

1.3 Description and Primary System Components. The photolithographic mask aligner is to be used to transfer patterns from a fused silica mask to a photo-active polymer film coating a substrate using contact photolithography. This process utilizes deep ultraviolet (DUV) light to define a pattern in photoresist that, with subsequent processing, allows the construction of 2 -dimensional devices with sub-micrometer resolution. This system will be used in a clean-room environment by a restricted group of trained operators. This specification is organized by describing the three major components of the mask aligner system: 1) a mechanical stage supporting the sample and mask and allowing alignment to be carried out between the two, 2) an optical exposure system capable of directing DUV radiation to the sample for a fixed and programmable period of time, and 3) a computerized topside video microscope system to be used during alignment of the sample to the mask. The requirements for each of these components follow.

Section 2. Mechanical Subsystem Requirements

2.1 Sample Size. The mask aligner must be capable of aligning and exposing silicon wafers having dimensions of 1) 2 inches diameter x 13 – 22 milli-inches thick, 2) 3 inches diameter x 13 – 22 milli-inches thick, and 3) 100 millimeters diameter x 475 – 575 micrometers thick and 4) 150 millimeters diameter x 585-725 micrometers thick. (These dimensions are necessary for minimum performance capability. A wider range of capability for an instrument does not preclude consideration for purchase.)

2.2 Mask holder. The system must be capable of supporting 4-inch square x 0.060 – 0.090 inch thick masks and, with minimal additional components, masks up to 7-inch square. Mask loading and unloading must be simple allowing a minimum of instrument downtime.

2.3 Wafer-Mask Alignment. The system must allow relative mask-sample motion in x,y,z and θ directions. (The x-y plane is defined as the plane of the mask; the z-direction is normal to the mask; θ is the angle measured from the x-axis in the x-y plane.)

Wafer-mask minimum motional range, x direction: ± 10 mm (20 mm range)
Wafer-mask minimum motional range, y-direction: ± 5 mm (10 mm range)
Wafer-mask minimum motional range, z-direction: 0-300 micrometers, minimum
Wafer-mask θ range: ± 5 degrees (10 degrees total)

Position of the sample or mask in x, y, and θ directions is to be precision micrometer-driven; chessman-type or joy-stick positional systems are not acceptable.

2.4 Wedge-error compensation. The system must automatically compensate for mask/sample non-planarity (also known as wedge-error). Ball and calotte systems of obtaining planarity are not acceptable.

2.5 x-y-θ Mechanical Resolution. The system must be capable of positioning a wafer relative to the mask to a resolution of 0.15 micrometer or less using the x-y-θ alignment micrometer controls.

2.6 X-y Shift Z-Movement. The shift in the x and/or y directions (relative to the mask) occurring as a result of motion of the wafer over the full range of z must be less than 0.1 micrometers, absolute.

2.7.1 Exposure Modes, Description. The exposure mode refers to the nature of the wafer/sample interface during exposure. *Pressure contact* mode applies a controllable and settable pressure to the mask-substrate interface through mechanical means or through the application of pressurized gas on the mask and/or wafer causing a compressive force between the mask and wafer. *Vacuum contact* is achieved by applying a vacuum to the interface region between the mask and substrate. *Proximity* mode refers to a user-programmable (or settable) distance between the wafer and substrate.

2.7.2 Exposure Modes – Requirements. The instrument is to provide pressure, vacuum and proximity contact exposure modes having the following specifications.

2.7.2.1 Pressure contact minimum pressure range: 0.02 – 1.0 N/cm^2, adjustable.
2.7.2.2 Vacuum contact: adjustable from 0 - 200 mbar absolute.
2.7.2.3 Proximity mode wafer-mask gap range: 1 – 100 micrometers, adjustable with 1 micrometer resolution or less with wedge-error compensation active.

2.8 Flat alignment. The stage must be capable of aligning the wafer flat to a mask edge to within ±2 degrees.

Section 3. Optical Subsystem Requirements.

3.1 General Description. The optical subsystem directs deep ultraviolet radiation from a source to the sample under time-programmable control. The mask aligner will be attached to an excimer laser source provided by a third party that produces 193 nanometer wavelength radiation. The optical subsystem must accept this radiation, process it optically via expanding and homogenizing lenses, and direct the radiation to the wafer.

3.2 Input beam characteristics. The excimer laser to be used as a DUV light source is the GAM EX100/1000. It has the following beam characteristics

Wavelength: 193 nanometers
Max average power: 35 Watts
Pulse length: 15-20 nanoseconds
Beam size: 9 x 3-5 millimeters
Beam divergence: 0.4 x 0.8 milliradians

The laser will be mounted directly to the mask aligner with no reflecting mirrors or beam conditioners.

Refer to GAM Laser, Inc., Orlando, FL (www.gamlaser.com) for more details.

3.3 Laser electronic interface. The mask aligner system must provide an electronic digital control signal to the laser system to initiate and halt the firing of the excimer laser. The digital control signal should be a TTL gated pulse that initiates firing of the laser on transition from low to high and maintains firing for the duration of the high level. Upon returning to the low level the laser will discontinue firing. (Other triggering and control mechanisms may be considered.)

3.4 Exposure time range/resolution. The minimum exposure time range required is 0 – 999 seconds and programmable in intervals down to 0.1 seconds.

3.5 Optical wavelength compatibility. The optical components of the mask aligner must be compatible with 193 nm ultraviolet radiation.

3.5 The system must have field-demonstrated capability of interface between the mask aligner and an excimer laser system. Beta-test systems are not acceptable.

3.6 Exposure area uniformity. The system must provide a 4 inch diameter area of uniform intensity. The intensity variation in this region is to be less than ± 5% from nominal. The system must be capable of exposing a 6 inch diameter wafer.

3.7 Nitrogen purge. The light-path assembly must be capable of being purged with dry nitrogen gas.

3.8 Safety. The system must meet industry and governmental guidelines for safety and prevention of exposure to 193 nanometer radiation. Specifically, but not exclusively, the system must follow guidelines enumerated by SPAWAR INST 5100.12B and ANSI Z136.1.

Section 4. Video Microscope Requirements

4.1 General. The video microscope subsystem will allow the operator to visually align features on the wafer to corresponding features on the mask. The system must display the alignment features on a video or computer monitor and provide simultaneous imaging and display of at least two alignment marks at different positions on the mask.

4.2 Dual focus operation. The microscope system must be capable of aligning the mask and substrate using dual focus mode. In this mode alignment is made with a gap between the wafer and substrate. First, an image of the mask alignment mark is captured to computer followed by a focus to the substrate plane. The wafer is aligned to the superimposed video-captured mask image using the x, y and θ micrometers. The wafer is then brought into the appropriate exposure mode for exposure of the photoresist. The system must be capable of displaying the wafer and mask in pressure and vacuum contact modes prior to exposure.

4.3 Objective magnification range. Each channel of the video microscope is to have a minimum of three, turret-mounted objectives for sample imaging. The lowest image magnification must be less than 100X; the highest image magnification must be greater than 740X.

4.4 Working distance. The objective lenses must operate with a minimum 7 millimeter working distance.

4.5 Objective separation. The objectives must be capable of variable separation between 46 – 90 millimeters center-to-center (minimum).

4.6 Travel Range. The microscope stage must be capable of traveling through a range of 100 millimeters in each of the x and y directions.

Section 5. Additional support items.

5.1 Vibration isolation table. A vibration isolation table is required that will conveniently support the mask aligner system. The table is to be air-operated capable of operation with 80 psi (pounds per square inch) air.

5.2 Intensity meter. The vendor shall supply a calibrated intensity meter and sensor capable of measuring 193 nm wavelength radiation intensity at the wafer plane. The sensor must be capable of measuring light intensity over the central 4 inch exposure region at the wafer plane.

5.3 Training. The vendor will provide training on the operation of the instrument to up to five researchers, upon installation at NRL, of the mask aligner-laser system.

5.4 Warranty: Offerors shall offer the Government at least the same warranty terms, including offers of extended warranties, offered to the general public in customary commercial practice.

5.5 Documentation: NRL requires two (2) copies of an operator manual for the photolithographic mask aligner system.

Section 6. Options

6.1 Flow hood. The vendor is to supply a flow hood that will provide a locally clean environment to Class 100 or better. Input air will be from the laboratory Class 1000 air supply.

6.2 150 mm exposure optics. The vender will configure the system to for ±5% uniformity over a 150 millimeter diameter.

6.3 Color CCD microscope. The video microscope will provide color image to either a computer monitor or color video monitor for alignment of wafer and mask features.

6.4 Image recognition system. The vendor will supply an image recognition system that can provide quantitative measure of misalignment between the wafer and mask during the alignment process.